A Novel Experiment for in-situ Planar Biaxial Studies  
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Advanced alloys, such as lightweight metals and shape memory alloys, are becoming increasingly important to the advancement of many industries. They often possess complex microstructures that result in anisotropic and asymmetric behaviors, often due to twinning and phase transformation of low symmetry crystal structures. Residual stresses from these deformation mechanisms result in path dependent behavior. Because of this, their three-dimensional mechanical properties and mechanisms of deformation cannot be fully understood through uniaxial loading. To elucidate these behaviors, a custom planar biaxial load frame capable of in situ X-ray and neutron diffraction experimentation has been built. It’s design allows for 262° of sample rotation while maintaining sample center of mass position with 50 µm. The instrument was also designed to study full plane stress yield and transformation loci.

In cruciform shaped biaxial test specimens, such as that shown in Fig. 1, the stress state in the gage is inherently influenced by the geometry, resulting in macroscopic stress calculation complexities not present in uniaxial specimens. In situ diffraction capabilities provide an advantage in determining exact gage stress state by probing stress states of grains within the gage. Many previous planar biaxial experiments have primarily focused on tension-tension loading of sheet metals. Thus, the first challenge in executing these experiments was designing specimen geometries capable of planar biaxial compression-compression, tension-compression, and tension-tension. Design and optimization of cruciform shaped specimens was accomplished using finite element analysis (FEA), mechanical testing, and digital image correlation (DIC). Plane stress analytic solution, maximum stress, and load distribution criteria were used to perform parametric optimization of the leading design.

![Fig. 1 Cruciform shaped planar biaxial specimen geometry with a reduced thickness gage section](image-url)